IS 4987 (1994): Recommendations for establishing net work of raingauge stations [WRD 1: Hydrometry]

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भारतीय मानक

वर्षामापी स्टेशनों के नेटवर्क स्थापना की सिफारिशें

(पहला पुनरीक्षण)

Indian Standard

RECOMMENDATIONS FOR ESTABLISHING NETWORK OF RAINGAUGE STATIONS

(First Revision)

UDC 551·508·7 : 551·501

BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

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Price Group 2

Ground Water and Preliminary Investigation Sectional Committee, RVD 3

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Ground Water and Preliminary Investigation Sectional Committee had been approved by the River Valley Division Council.

Hydrometeorological data are collected to provide hydrological and meteorological input for assessing, developing and managing water resources of the country. They are also used for forecasting flood discharges, low flow and monthly as well as yearly discharges for operation of reservoirs and hydroelectric plants. Since rainfall is the most important factor in the problems of hydrology, for correct assessment, the project authorities have not only to examine the reliability of the past data collected but may also have to augment the network for obtaining the representative water resource information of the project catchment. The main purpose in planning a hydrometeorological network is the provision of meteorological support to elucidate the hydrology of the river basins, or hydrological units, under consideration. The planning of networks should, therefore be closely related to the physical factors which affect hydrology, namely, topography, morphology, precipitation, geology, land use and soil type.

In the formulation of this standard due weightage has been given to international co-ordination among the standards and practices prevailing in different countries, in addition to relating it to the practices in the field, in this country. This has been done by deriving assistance from the following publications:

Guide to hydrometeorological practices fourth edition, 1981 World Meteorological Organization, Geneva

Hydrologic networks and methods, flood control series No. 15, 1960. Economic Commission for Asia and the Far East and the World Meteorological Organization

(Transactions of the inter-regional seminar on hydrologic networks and methods, Bangkok.)

This standard was first published in 1968. Based on advancements in technology it is being revised based on the suggestions received from India Meteorological Department.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

RECOMMENDATIONS FOR ESTABLISHING NETWORK OF RAINGAUGE STATIONS

(First Revision)

1 SCOPE

1.1 This standard lays down recommendations for distribution, density and representativeness of network of raingauge for hydrometeorological studies.

2 REFERENCES

The following Indian Standards are necessary adjuncts to this standard:

IS No.	*Title*
4986 : 1983	Code of practice for installation of rain gauge (non-recording type) and measurement of rain (*first revision*)
5542 : 1969	Guide for storm analysis

3 GUIDING PRINCIPLES FOR DETERMINING THE ADEQUACY OF THE NETWORK OF RAINGAUGE STATIONS

3.1 For any type of hydrometeorological study it is imperative that an optimum design of the network of raingauge stations is determined taking into consideration various factors that influence the specific purpose for which such designs are envisaged. Orography of a place and rainfall variability therein, are two most important factors for designing the network.

3.2 There are two types of network namely, primary and secondary network. A primary network aims at establishing a permanent network of rain gauges for climatological purposes. A secondary network is purely of a temporary nature for meeting specific requirements of certain major projects. The idea of secondary network is to collect the data for as long a period as the project continues, or alternatively continue till a stable relationship can be developed between the stations of temporary and primary networks.

3.3 In plains, one raingauge up to 500 km^2 shall be sufficient. However, if the catchment lies in the path of low pressure systems which cause precipitation in the area during their movement, the network should be denser, particularly in the upstream.

3.4 In not too elevated regions with average elevation one kilometre above sea level, the network density shall be one raingauge in 250 km^2 to 400 km^2. New raingauges shall be installed according to IS 4986 : 1983. The denser network of raingauges in certain regions of the catchment and its spareness at others will result in biased water resources assessment. In such cases the distribution may be made uniform by taking such raingauge stations which will give Thiessen polygons (*see* IS 5542 : 1969) of more or less equal weight. No station pertaining to pockets of heavy precipitation should be excluded from consideration.

3.5 In areas predominantly hilly and where very heavy rainfall is experienced care shall be taken in the setting up of the network raingauge stations. These water sheds are the most important areas of the catchment. They are also the areas of extreme rainfall variability. The normal network, if economically feasible, should be one raingauge in not more than 150 km^2, the denser network being preferable. However, in areas where the catchment is in the rain shadow of high barriers, this precaution may not be necessary.

3.6 Since most of the multipurpose river valley projects are connected with irrigation, hydropower and flood control, automatic recording raingauges may be installed in the upper reaches of the catchment of the water-shed. The information about the intensity of rainfall, as could be obtained from the self-recording raingauges, may be utilized for obtaining the flood hydrograph immediately dowstream, where the tributaries are leaving the ravines and entering the main-stream. Here again, the self-recording raingauges may be fixed up after taking into consideration the economic feasibility, the requirement of the project and the necessity for obtaining short duration intensities. However, it is desirable to have at least 10 percent of the raingauge stations equipped with self-recording type of raingauges.

3.7 In some cases it may not be necessary to design dense networks because information from meteorologically and geologically homogeneous catchments around the project

catchment, with better network may already be available. It should, therefore be examined wheather information about such catchments already exist and from the rainfall analysis already carried out for the catchment whether it could be possible to obtain the design storm, fulfilling those requirements.

4 SATURATED NETWORK DESIGN

4.1 In addition to the general considerations given in **3**, for setting up raingauges in any area, one of the factors that should guide the fixation of the actual network of raingauges is the importance of the project itself and the accuracy with which rainfall over the catchment is to be assessed. If the project is very important and the rainfall over the area has to be assessed with the maximum possible accuracy, then a network of raingauges shall be set up, such that, any addition to it will not appreciably alter the rainfall assessed. Such a network is referred a saturated network. In order to arrive at a saturated network of raingauges for any catchment or area, the procedure given in **4.1.1** shall be adopted.

4.1.1 Rainfall in the area for a few storms shall be assessed, taking into account all the raingauges (100 percent) in the catchment, 80 percent of raingauges, 60 percent of the raingauges, etc. The raingauges chosen shall be equitably distributed in the area. A graph between the number of raingauges taken into account and the storm rainfall may be drawn for each one of the storms separately. If it is noticed that the assessed storm rainfall does not change appreciably, even if raingauges considered are slightly less than the total number existing, then it indicates that the existing network is near the saturated value. If the assessed storm rainfall changes rapidly with change in the number of gauges considered, it shows that the network is far from saturated and the number of gauges may be increased to such a stage that any further increase in the gauges does not appreciably alter the assessed storm rainfall.

5 OPTIMUM NETWORK DESIGN

5.1 The aim of optimum network design is that, by interpolation between values of different stations, it should be possible to determine with sufficient accuracy, for practical purposes, the characteristics of the basic hydrometeorological elements at any point of interest. By characteristics is meant, all quantitative data, averages and extremes that define the statistical distribution of the hydrometeorological elements studied.

5.2 Adequacy of Raingauge Stations

When the mean rainfall is calculated by simple arithmetical average, the optimum number of raingauges is obtained by the following equation:

$$N = (C_V/P)^2$$

where

N = optimum number of raingauge stations,

C_V = coefficient of variation of the rainfall values of the existing raingauge stations, and

P = desired degree of percentage error in the estimate of basin mean rainfall.

5.2.1 The procedure for working out this optimum number for a typical case has been explained in Annex A.

5.2.2 The mean rainfall shall be estimated correctly within 10 percent (P = 10). With the decrease in the percentage error, the adequate number of raingauges or the raingauge network would also increase. This would increase the operating cost. Therefore, in establishing the optimum number of raingauges, the problem of operating cost shall also be taken into consideration. However in case of special requirements, suitable methods may be used.

5.3 Allocation of Additional Raingauge Stations

The prob'em of allocating additional raingauge stations depends upon the spatial distribution of existing raingauge stations, and the variability of rainfall over the basins. With the limitations of accessibility to new sites and facilities available for maintaining these stations, additional raingauges should be located so as to have an even distribution over the entire basin. The allocation should take into account the variability of the mean monthly and annual rainfall over the basin. The mode of allocation has been explained in the example given in Annex A.

6 MINIMUM NETWORK DESIGN

6.1 In many areas it may not be feasible to design even an optimum network as given in **5**. In such cases, a minimum network may have to be designed and the distribution of the available raingauges in the various catchments require a good climatological knowledge. For example, in a catchment lying on the leeward side of the prevailing moisture laden wind, it is not necessary to provide a better network immediately after the hump at the cost of the lower reaches, where rainfall is heavier.

6.2 Special care shall be taken for planned development of networks which would not contribute towards faulty assessment of water resources and flood producing potential.

6.3 In plain there should be at least one raingauge station for an area of 750 km². In hilly regions one raingauge station normally represent an area between 100 km² – 250 km². In arid areas, one raingauge station should normally represent an area between 1 500 km² – 10 000 km².

7 PERIOD OF DATA AND UNIFORMITY OF OBSERVATIONS

7.1 The period of precipitation record required to analyse a problem within a reliable safety factor, depends upon the nature of the problem and the time variations in precipitation in the concerned region. For example, if the frequency distribution of mean annual precipitation depth at a point or over an area becomes essentially stable after a certain period, the addition of further years of observations does not significantly add to the accuracy. The length of the period of record needed to achieve a stable frequency distribution varies by seasons and regions. From experience, the following tentative estimates of the number of years needed to obtain a stable frequency distribution of precipitation amount are recommended:

Catchment Layout	*Islands*	*Shore*	*Plains*	*Mountains*
No. of years	30	40	40	50

7.2 Although there might be justification in continuing observations at selected stations indefinitely, unlimited operation of all stations may not be possible from financial considerations. The need to retain all gauges of an existing network should be reviewed from time to time, and the station for which future data could be estimated with sufficient accuracy through correlation with records at one or more neighbouring stations, may be discontinued. It should be remembered that undue hurry in closing down a raingauge station as soon as the project report is ready, may lead to disastrous results unless stable data, comparable to neighbouring stations, has already been collected from it.

ANNEX A

(*Clauses* 5.2.1 *and* 5.3)

AN EXAMPLE OF THE PROBLEM OF ADEQUACY OF RAINGAUGE STATIONS WITHIN A RIVER BASIN AND ALLOCATION OF ADDITIONAL RAINGAUGES

A-1 DETAILS OF RIVER BASIN

A-1.1 A typical river basin with four raingauge stations within the catchment and four outside is shown in Fig. 1.

A-2 ESTIMATION OF OPTIMUM NUMBER OF RAINGAUGES

A-2.1 The various steps involved in the estimation of optimum number of raingauges are described below:

a) Calculate the total rainfall in millimetres, of the 4 raingauges situated within the catchment area. Denote this by T:

$$T = 800 + 540 + 445 + 410 = 2\ 195$$

b) Calculate the mean rainfall in the catchment given by:

$$m = \frac{T}{4} \qquad \frac{2\ 195}{4} = 548{\cdot}75$$

c) Calculate the sum of squares of the rainfall of these 4 raingauges as $SS = (800)^2 + (540)^2 + (445)^2 + (410)^2 = 1\ 297\ 725$

d) Calculate as follows:

$$\frac{T^2}{4} = \frac{(2\ 195)^2}{4} = 1\ 204\ 506$$

e) Calculate the variance (square of standard deviation) of the rainfall denoted by S^2:

$$S^2 \frac{SS - \frac{T^2}{4}}{4 - 1} = \frac{1\ 297\ 725 - 1\ 204\ 506}{3} =$$

$$= 31\ 073$$

f) Calculate the coefficient of variation denoted and given by:

$$C_v = \frac{100\ (S^2)^{1/2}}{m}$$

$$= \frac{100 \times [31\ 073]^{1/2}}{548{\cdot}75} = 32{\cdot}12$$

g) Optimum number, N of raingauges that would be necessary to estimate the average rainfall with a percentage error less than or equal to 10 percent ($P = 10$) is obtained by:

$$N = \left[\frac{C_v}{P}\right]^2 = \left[\frac{32 \cdot 12}{10}\right]^2 = 10 \cdot 32 = 11$$

A-2.2 Thus, the 4 existing raingauges are not adequate for estimating the average catchment rainfall within an allowable error of 10 percent or less. The optimum number should be at least 11, so that 7 (= 11 − 4) additional raingauges within the catchment area are required.

A-3 ALLOCATION OF ADDITIONAL RAINGAUGES

A-3.1 For allocating the additional number of raingauges in the basin, proceed as follows:

a) Draw isohyets at equal intervals taking into consideration the rainfall of the stations outside the catchment. Isohyetal lines for 380 mm, 510 mm, 640 mm, 770 mm and 900 mm are drawn as shown in Fig. 1.

b) Measure the area bounded by two consecutive isohyets within the catchment by a planimeter. The proportionate areas of the different isohyetal zones marked by by X_1, X_2, X_3, X_4 and X_5 are found to be: $X_1 = 0{\cdot}122\,9$, $X_2 = 0{\cdot}376\,0$, $X_3 = 0{\cdot}339\,2$, $A_4 = 0{\cdot}1\,021$, and $X_5 = 0{\cdot}059\,8$.

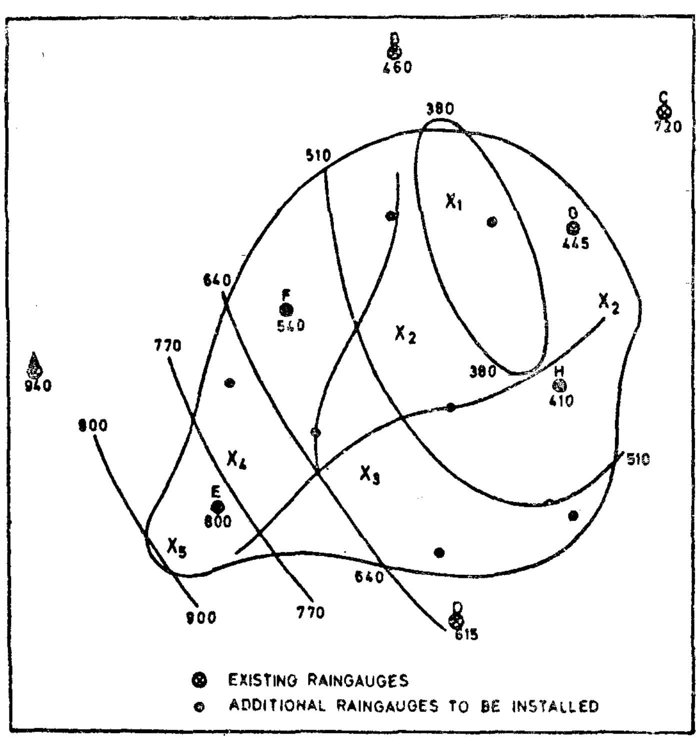
c) The 11 raingauges are to be allocated to different zones in proportion of their areas. Thus the number of raingauges in different isohyetal zones should be:

$X_1 = 1{\cdot}4$, $X_2 = 4{\cdot}1$, $X_3 = 3{\cdot}7$, $X_4 = 1{\cdot}1$ $X_5 = 0{\cdot}7$.

d) Calculate the additional number in each zone by subtracting the existing number from the total optimum number. These are shown below:

Zone	X_1	X_2	X_3	X_4	X_5	Total
Existing No.	0	2	1	0	1	4
Additional No. of raingauges	1	2	3	1	0	7
Total No.	1	4	4	1	1	11

A-3.2 The additional number of raingauges should be allocated randomly in each zone. In the absence of random number tables allocate them considering relative distance amongst the different raingauge sites, the accessibility, availability of part-time observers and discharge site, etc. The allocation has been done arbitrarily in the present case and the new sites are indicated by circles in Fig. 1.



All values in millimetres.

FIG. 1 DISTRIBUTION OF RAINGAUGES IN A TYPICAL RIVER BASIN

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